INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

M99/420/H(3)

CHEMISTRY

Higher Level

Friday 7 May 1999 (morning)

Paper 3 — 1 hour 15 minutes

A

Candidate name:	Candidate Category and Number:

This examination paper consists of 6 options.
The maximum mark for each option is 25.
The maximum mark for this paper is 50.

INSTRUCTIONS TO CANDIDATES

Write your candidate name and number in the boxes above.

Do NOT open this examination paper until instructed to do so.

Answer all of the questions from TWO of the options in the spaces provided.

At the end of the examination, complete box B with the letters of the options answered.

B

OPTIONS ANSWERED

C

EXAMINER	MODERATOR
/25	/25
/25	/25
TOTAL /50	TOTAL /50

D

IBCA
/25
/25
TOTAL /50

EXAMINATION MATERIALS

Required:
Calculator
Chemistry Data Booklet

Allowed:
A simple translating dictionary for candidates not working in their own language

Option C – Human Biochemistry

C1. Iodine index (iodine number) is defined as the number of grams of iodine able to react with 100 grams of a fat or an oil in an addition reaction.
The table below contains the values of iodine indexes for three fats/oils.

Fat / Oil	Iodine index
Coconut	8–10
Butter	26–45
Olive	74–94

(a) Explain the relationship between the iodine index and unsaturation, and select the most **saturated** fat/oil. *[2]*

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(b) Oleic acid [$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$] is commonly present in fats and oils. Calculate the iodine index of this acid according to the above definition. *[3]*

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(c) Which of the above fats or oils would you recommend to be part of a healthy diet? Justify your answer. *[2]*

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(d) State **three** functions of fats and oils in the human body. *[3]*

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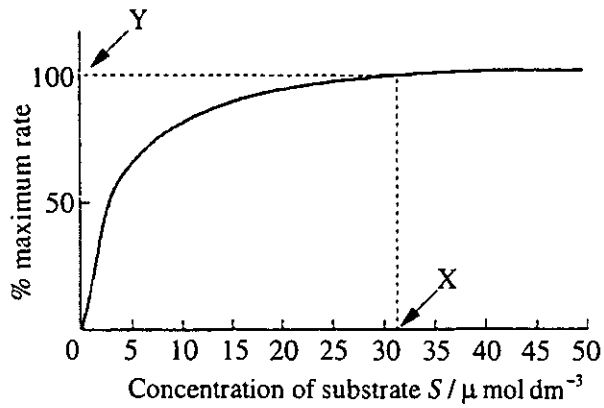
C2. The graph below represents the activity of an enzyme on the substrate *S*.



(a) What is the meaning of the point **Y**? *[1]*

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(b) Explain, on a molecular level, why the reaction rate increases with substrate concentration from **0** to **X** but remains constant thereafter. *[2]*

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(c) Define the Michaelis constant (K_m) and explain its significance. *[2]*

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(d) From the graph, determine the value of K_m. *[1]*

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C3. (a) Give the empirical formula of a monosaccharide and identify **two** functional groups that it possesses. *[3]*

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(b) Draw the straight chain formula of glucose. Describe the structural difference between α- and β-glucose and name the type of isomerism they exhibit. *[3]*

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(c) Write a balanced equation to represent the formation of a disaccharide from glucose. Explain how this process is extended to the formation of a polysaccharide such as starch. *[3]*

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Option D – Environmental Chemistry

D1. Ozone depletion in the upper atmosphere is currently of great concern.

(a) Write equations to show how ozone is produced and destroyed by natural processes in the upper atmosphere. Indicate clearly any differences in the conditions for its production and destruction. *[5]*

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(b) Give the mechanism by which ozone is destroyed by CCl_2F_2. *[3]*

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(c) Explain why ozone depletion is greater in polar regions. *[1]*

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D2. This question relates to 'acid rain'.

(a) Account for the fact that natural rain has a pH of around 5.6. Give a chemical equation to support your answer. *[2]*

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(This question continues on the following page)

(Question D2 continued)

(b) Because of pollution, acid rain may be 50 times more acidic than natural rain. Identify the **two** acids that cause this high acidity and indicate their origins. Show by means of an equation how **one** of these acids is produced. *[5]*

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(c) State **two** consequences of acid rain. *[1]*

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D3. Briefly describe the primary, secondary and tertiary stages of sewage treatment and indicate the types of pollutants removed by each. Explain why tertiary treatment is becoming increasingly important and state briefly the chemical basis of **one** type of tertiary treatment. *[8]*

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Option E – Chemical Industries

E1. (a) Aluminium is manufactured by the electrolysis of alumina dissolved in molten cryolite.

(i) Explain the function of the cryolite. *[1]*

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(ii) Give an ionic equation for the reaction at the anode during the electrolysis. *[1]*

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(iii) Explain with the aid of an equation why the anode slowly disappears. *[1]*

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(b) Explain how the production of pure alumina from bauxite takes advantage of the amphoteric nature of aluminium oxide. *[2]*

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(c) Give **two** properties **and** related uses which make aluminium an important metal in today's world. *[2]*

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(d) Despite aluminium being the most abundant metal in the earth's crust, it is frequently recycled. Give **two** reasons which favour recycling. *[2]*

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E2. (a) Give the radical mechanism for the manufacture of low density polythene and explain how the process conditions are altered to produce high density polythene. *[7]*

(b) Silicones are obtained by condensation polymerisation. Explain how this polymerisation differs from that used to obtain polythene. *[2]*

E3. Oil is used as an energy source and as a chemical feedstock.

(a) Name **one** compound obtained from oil which is used as a fuel and give an equation for its complete combustion. *[2]*

(b) Decane has been used as an energy source but has greater value as a source of other chemicals. Use an equation to show the formation of **two** organic products from the cracking of decane, $C_{10}H_{22}$. *[2]*

(c) Name the processes by which polythene is obtained from oil. *[3]*

Option F – Fuels and Energy

F1. (a) When coal is burned several gases are produced in addition to carbon dioxide. Write an equation for the combustion of an ***element*** in coal to form **one** of these gases. *[1]*

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(b) State how the emissions of the gas identified in (a) could be minimised *[1]*

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(c) In countries lacking natural gas reserves, coal is sometimes converted into synthesis gas, a mixture of carbon monoxide and hydrogen. Synthesis gas is then converted into liquid methanol, CH_3OH. Give **two** advantages of a liquid fuel compared with a solid fuel. *[2]*

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(d) (i) Write an equation for the complete combustion of methanol. *[1]*

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(ii) The standard enthalpies of formation, ΔH_f^0, for CO_2 and $H_2O(l)$ are -393.5 and -258.8 kJ mol^{-1} respectively. Use this information and Table 11 of the Data Booklet to calculate the enthalpy of combustion of 1 mol of liquid methanol. *[4]*

(iii) How would this value differ if the water were produced as a gas rather than as a liquid? *[2]*

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F2. (a) State the main difference between a chemical reaction and a nuclear reaction. *[1]*

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(b) List **three** components of a nuclear reactor, other than the fuel, and describe the role of each. *[6]*

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F3. (a) An important aspect of the nuclear industry is the disposal of radioactive waste. For highly radioactive waste the material is stored under suitable conditions until the activity has fallen to a safe level.

(i) ^{32}P is a β emitter. State what β particles are and name the element produced in this decay process. *[2]*

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(ii) Calculate the time taken for 32 g of ^{32}P of half life 14 days to become 1 g of the radioactive isotope. *[3]*

(b) Describe **two** other ways of dealing with radioactive waste. *[2]*

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Option G – Modern Analytical Chemistry

G1. Two compounds, **A** and **B**, having the same molecular formula, C_3H_8O, are methoxyethane and propan-2-ol respectively.

(a) Give the structural formula of **A** and **B**. *[2]*

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(b) A student said that the compounds **A** and **B** could be easily distinguished by ^1H NMR spectrometry.
Describe the ^1H NMR spectrum of:

(i) the ether **A**. *[3]*

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(ii) the alkanol **B**. *[3]*

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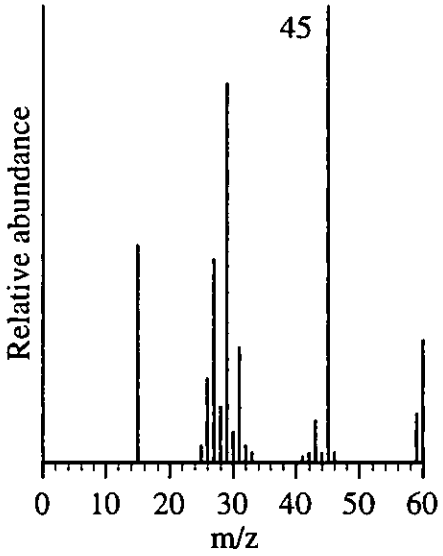
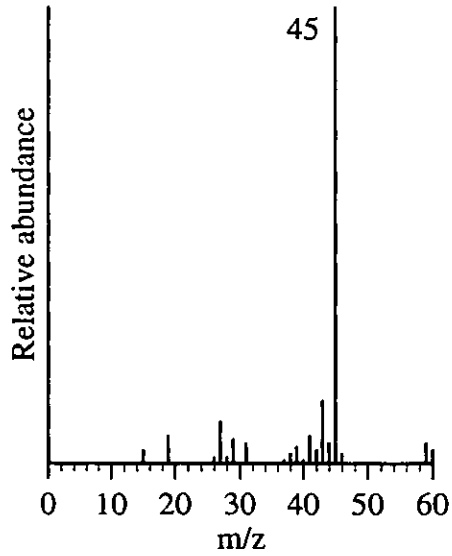
(Question G1 continued)

(c) (i) A second student who had access to a mass spectrometer argued that she could easily distinguish the compounds by their mass spectra.
The mass spectra are as follows:



Compound **A**



Compound **B**

Do you think the second student could identify correctly the two compounds from the spectra above? Explain. *[3]*

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(ii) Discuss the relative boiling points of **A** and **B**, and give a molecular-level explanation for any differences. *[2]*

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G2. (a) Infrared spectroscopy is a powerful tool for identifying organic compounds. State what occurs at the molecular level during the absorption of infrared (ir) radiation and identify the change that is necessary for ir absorption to occur. Discuss why infrared studies are particularly helpful in the characterisation of organic molecules. *[4]*

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(b) Use information in Table 18 of the Data Booklet to list the absorption regions expected for:

(i) ethanoic acid. *[2]*

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(ii) methyl methanoate. *[2]*

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(c) Identify the absorption listed in (b) which could be used to distinguish between these two compounds. Explain why the other absorptions could not be used. *[2]*

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(d) Identify the absorption listed in (b) which has the highest energy and calculate its wavelength in cm. *[2]*

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Option H – Further Organic Chemistry

H1. An organic compound, **P**, of molecular formula C_4H_8O reacted with 2,4-dinitrophenylhydrazine to form an orange precipitate.

(a) Give the name and structural formula of the functional group which is responsible for this reaction and deduce possible structural formulae for **P**. *[3]*

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(b) (i) Outline the mechanism for the addition of hydrogen cyanide to any isomer of **P** showing clearly the reacting species. *[3]*

(ii) Write the structural formula of the organic molecule obtained by the acid hydrolysis of the product of (b) (i) and suggest why it might be optically inactive. *[2]*

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H2. Both ethane and ethene react with bromine, although the conditions and mechanisms are different. Give the equations and conditions for these reactions. Outline the mechanism of **one** of these reactions. *[7]*

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H3. The mononitration and monobromination of benzene both occur by electrophilic substitution.

(a) Describe the experimental conditions in each case. For **each** reaction, give an equation to show the formation of the electrophile. *[6]*

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(b) Outline the mechanism of **one** of these reactions. *[2]*

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(c) Give the structure of the principal product formed during the dinitration of benzene. Explain your answer. *[2]*

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